

Photodetectors (of course)

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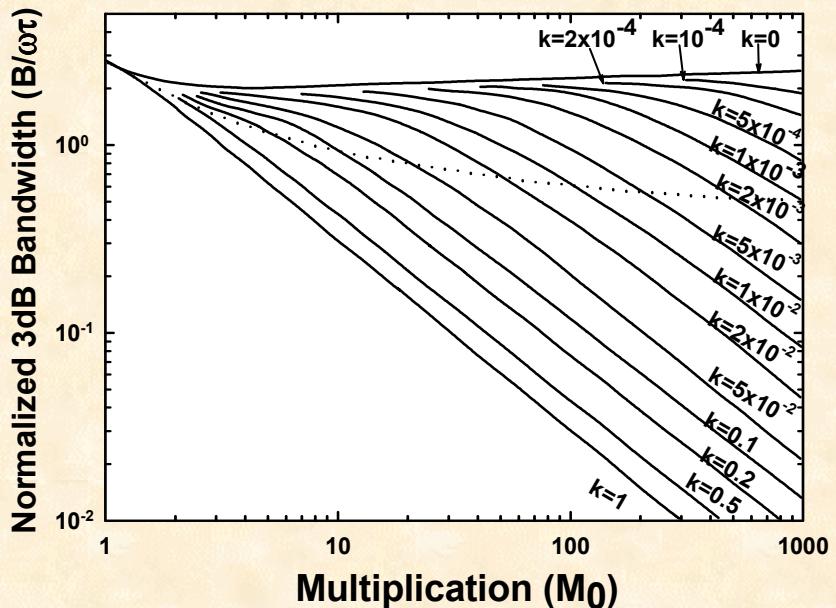
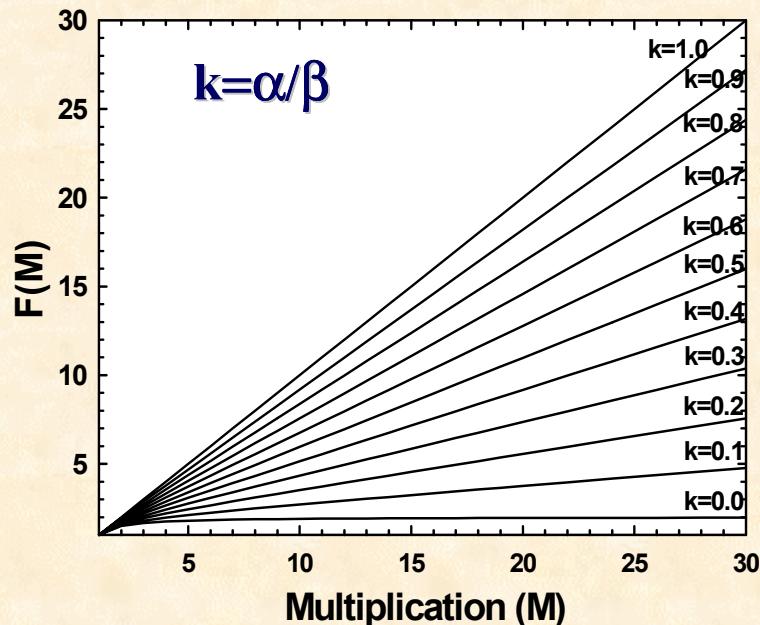


APD Noise

- **Noise spectral density**
- **Excess noise factor**

PIN Shot Noise

$$S = \overbrace{2eI_{ph}R(\omega)} M^2 F(M)$$
$$F(M) = k_{eff}M + (1 - k_{eff})(2 - \frac{1}{M})$$

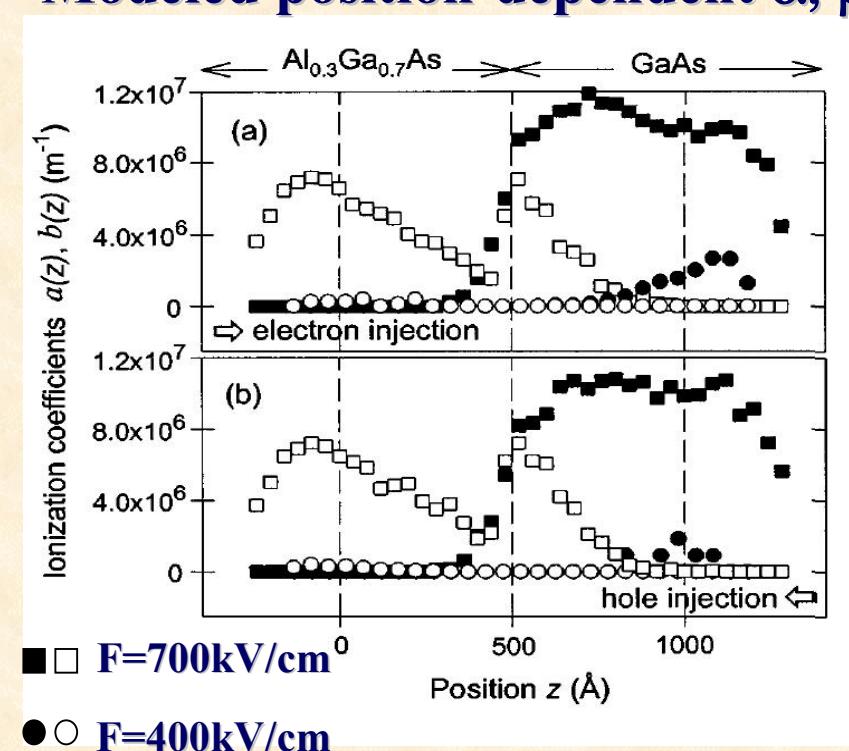
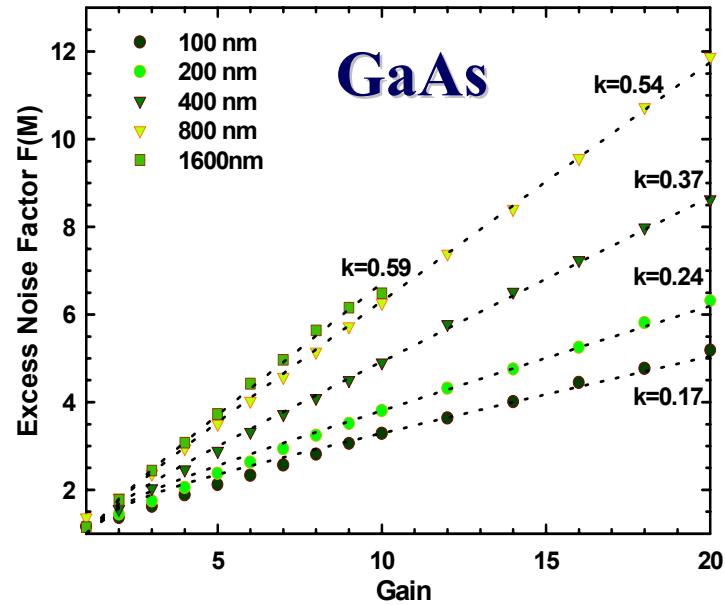


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Motivation –

- Thin-multiplication-region APDs
- Modeled position-dependent α , β

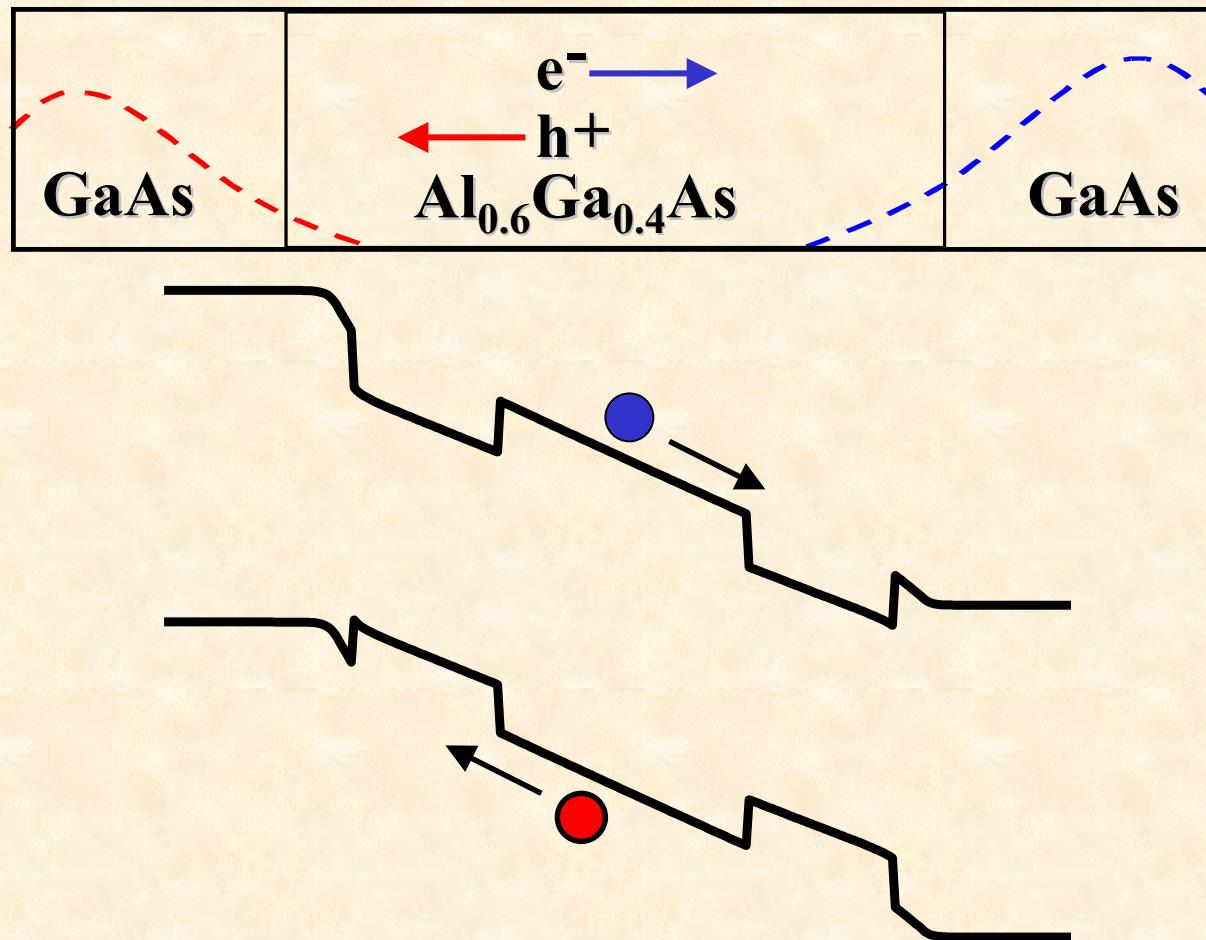


C. K. Chia et al., J. Appl. Phys. vol. 84, no. 8, 1998

- Low noise achieved
 - “dead space” effect
- Tunneling limitation
- Strong Ionization near the edge of thin multiplication-region APDs



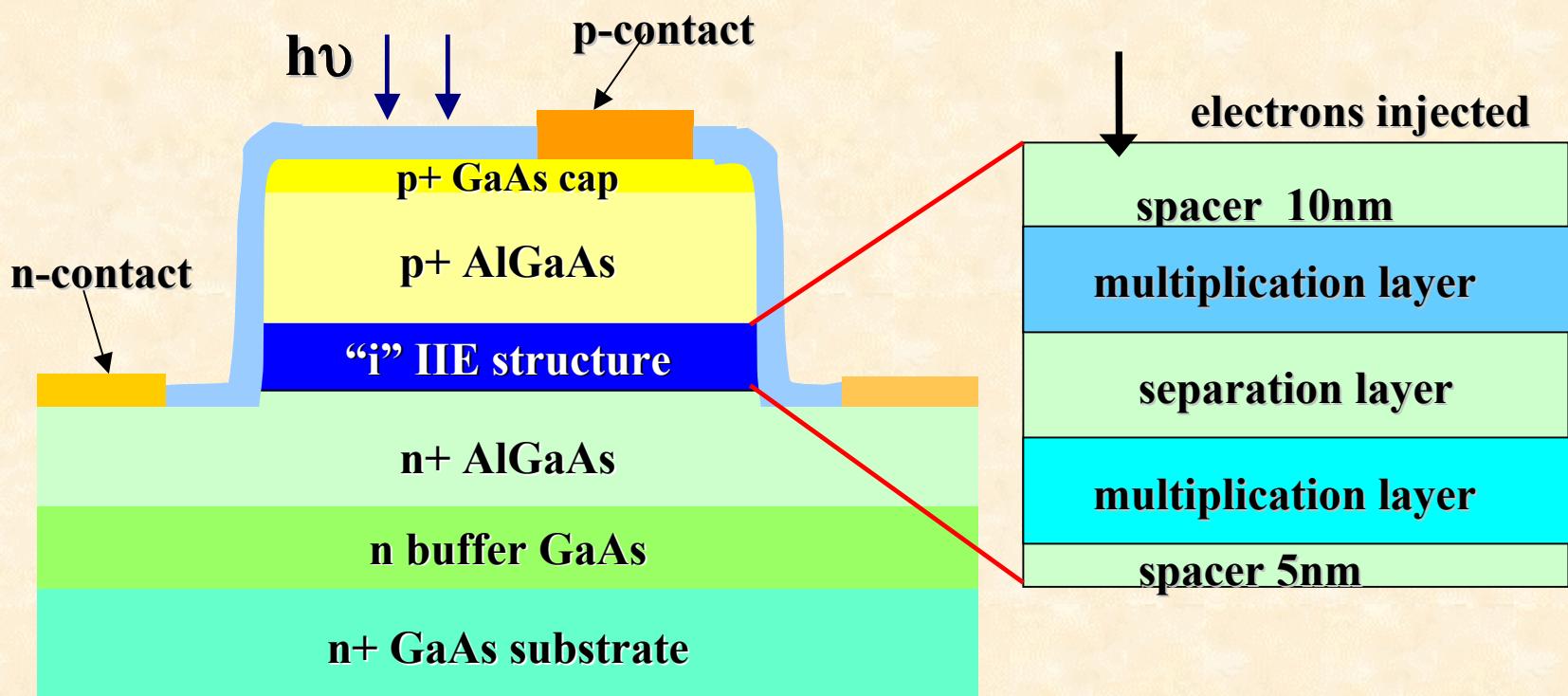
Impact-Ionization Engineered APDs



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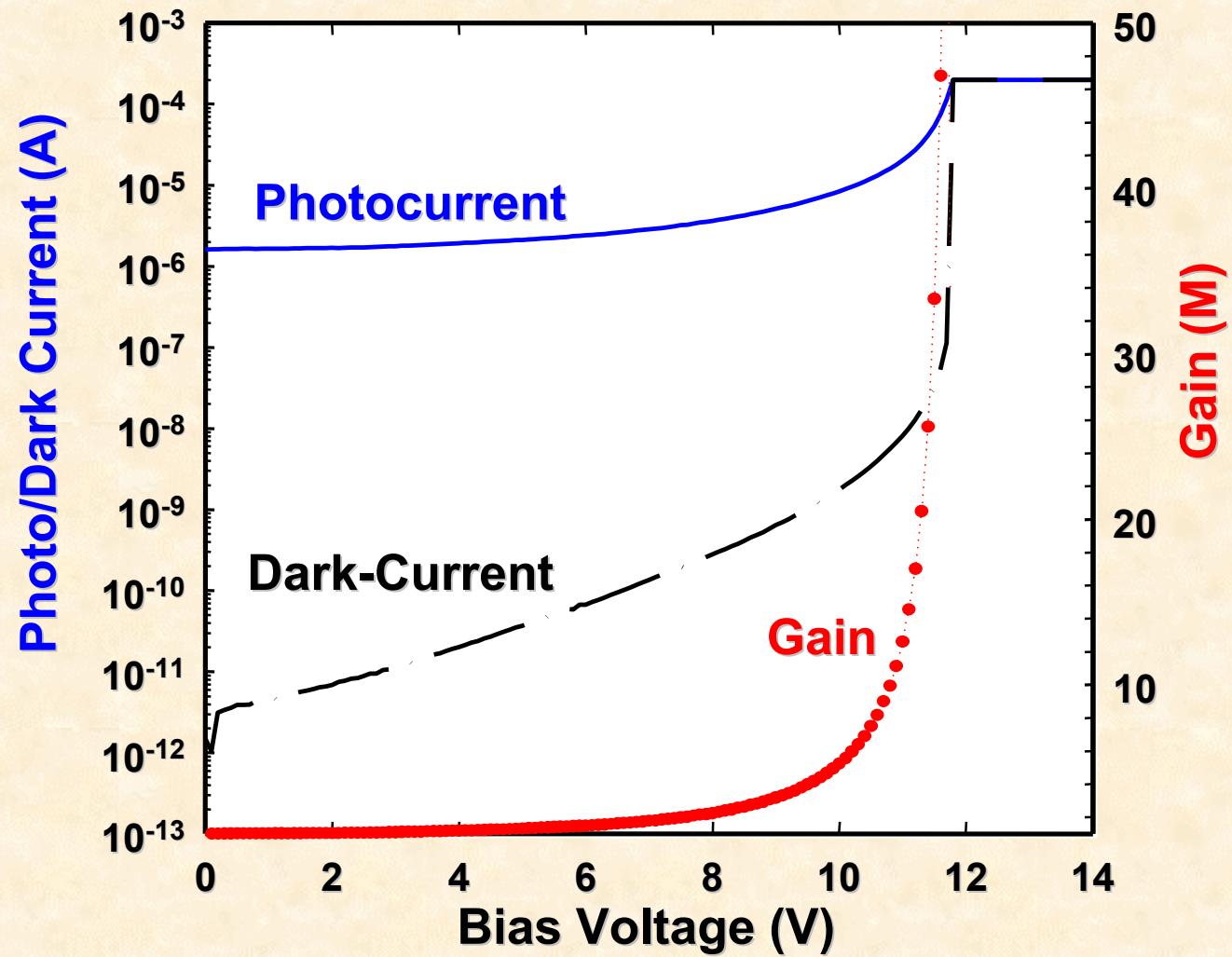
Device Structure – Twin-well



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Typical I-V/Gain Curves



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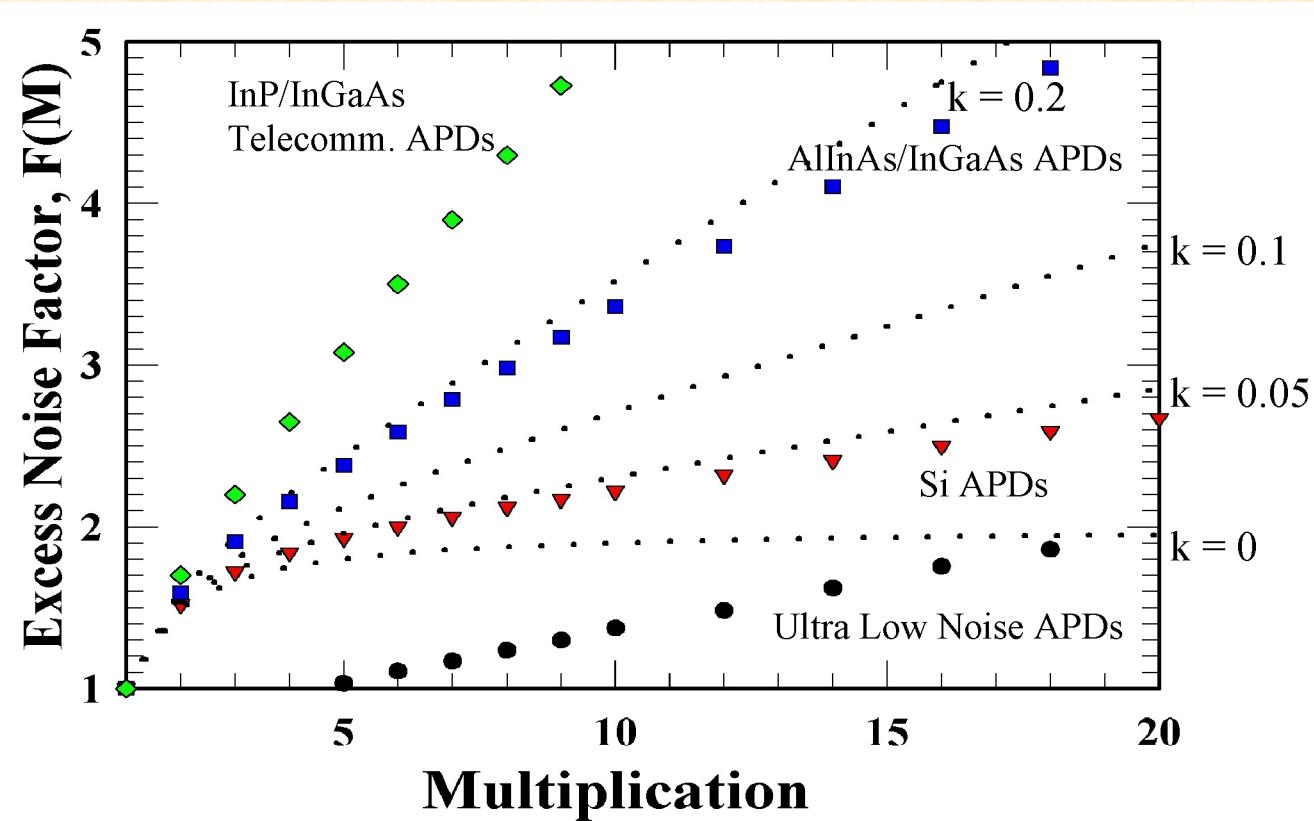
Avalanche Photodiode Noise

PIN Shot Noise

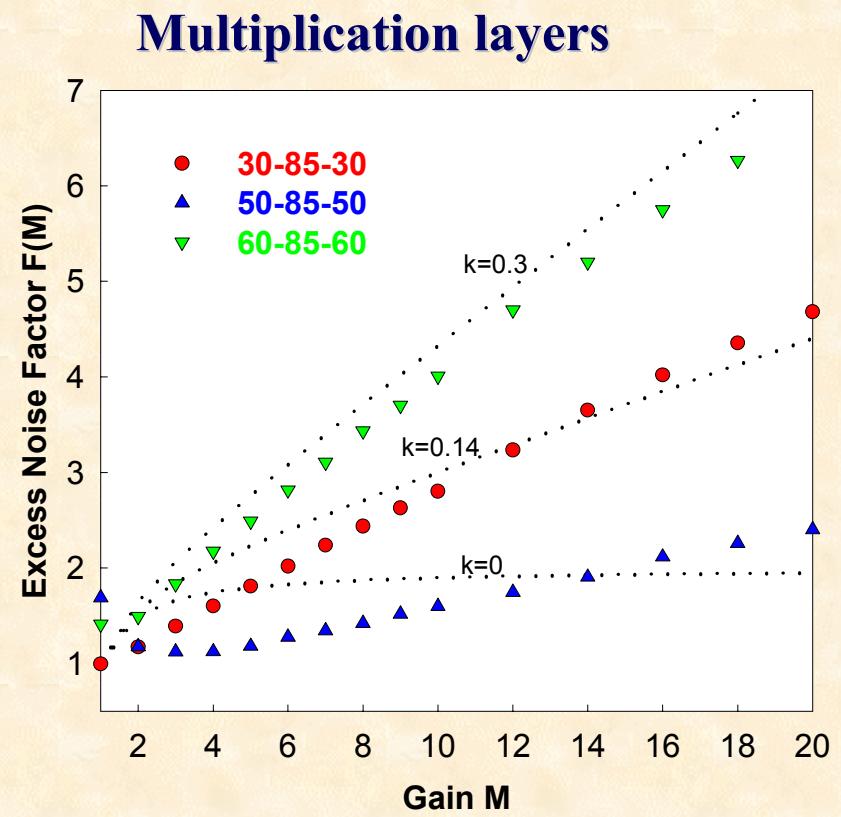
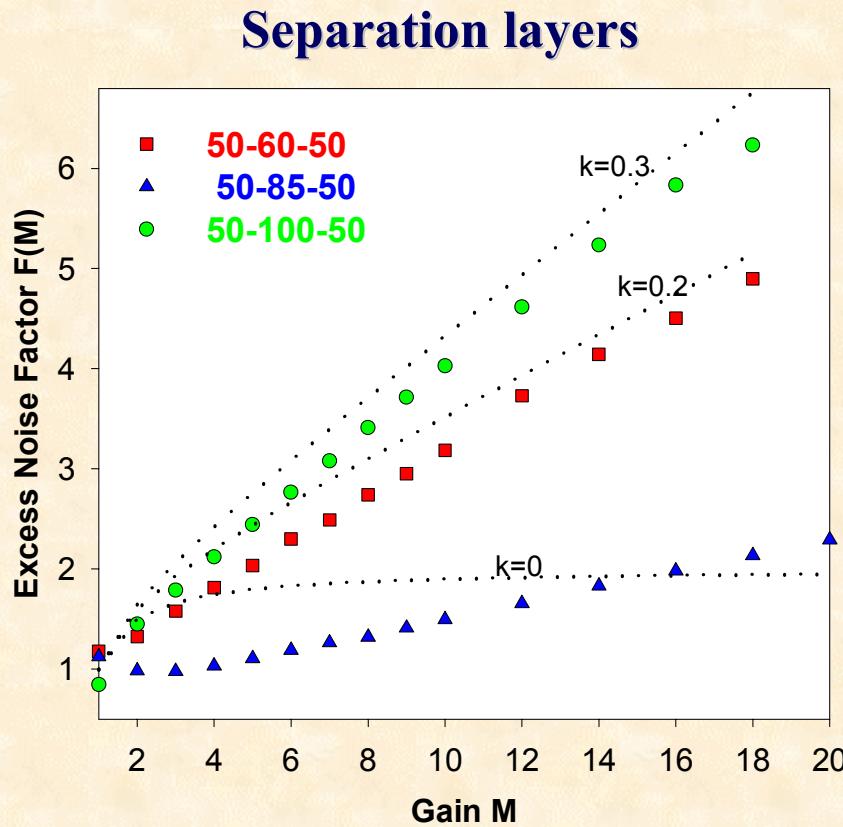
$$\phi = \left[2qI_{ph}R(\omega) \right] M^2 F(M)$$

$$F(M) = k_{eff}M + |2-1/M| (1 - k_{eff})$$

$k_{eff} = \alpha/\beta$ Ratio of the ionization coefficients



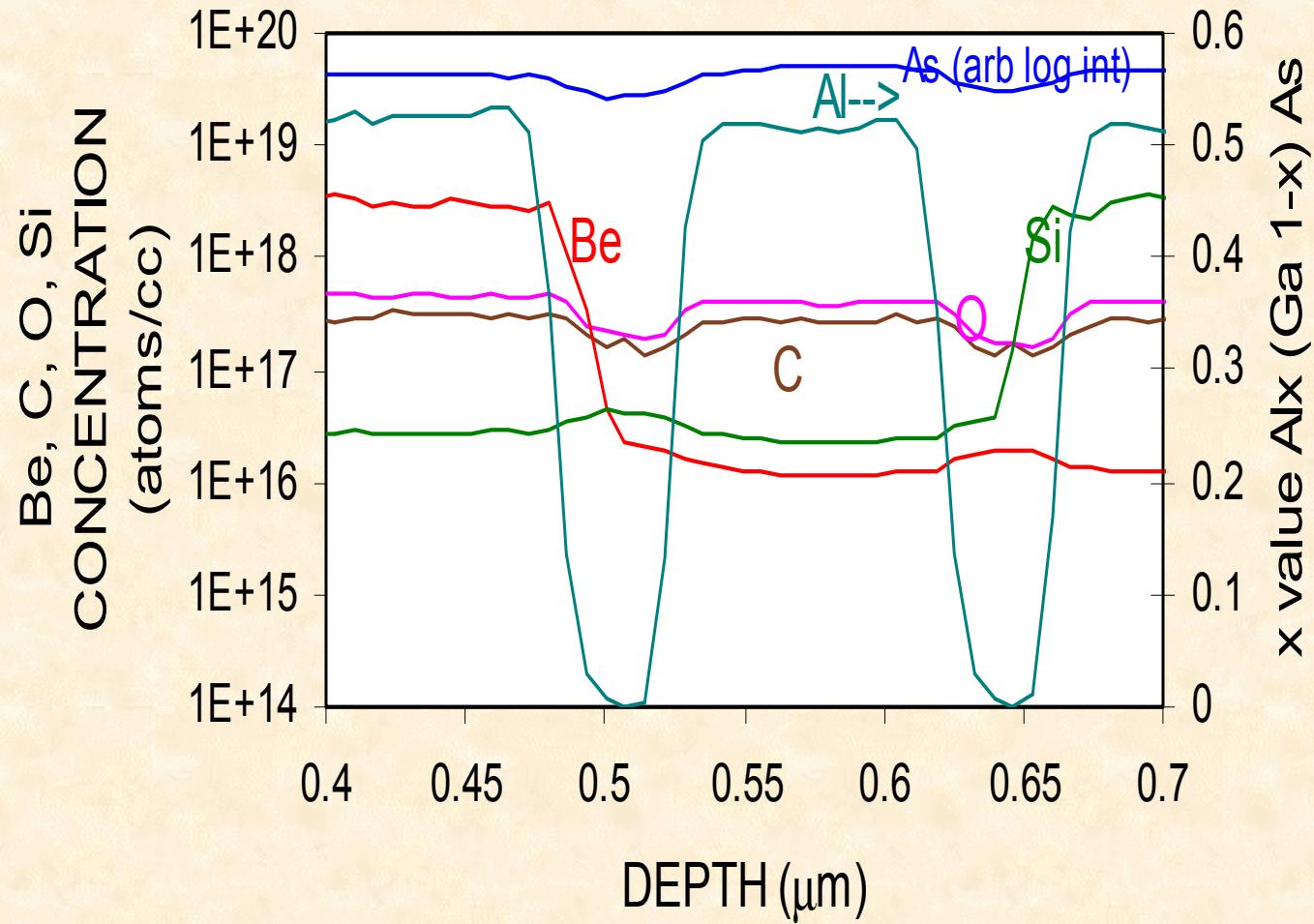
Twin-well: variation on layers



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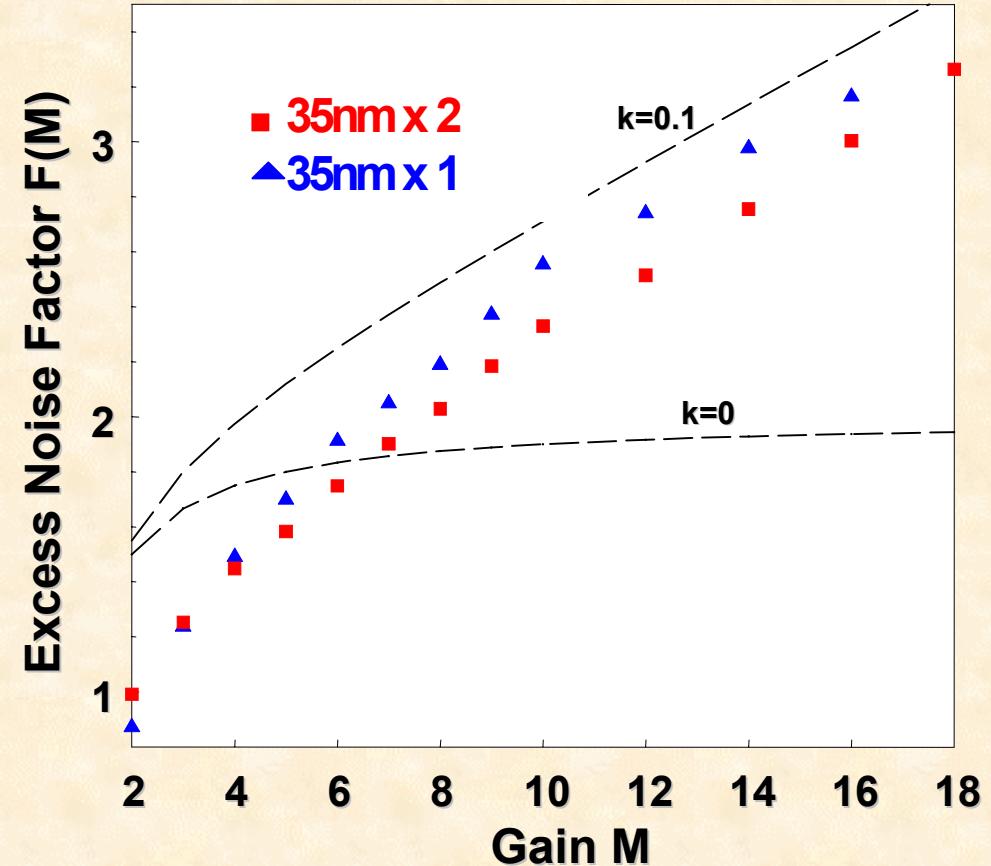
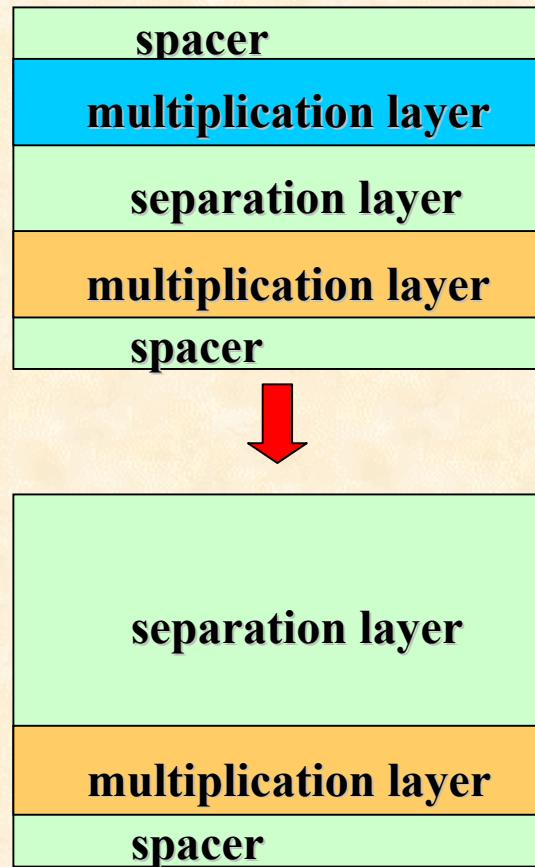
Dopant Diffusion - SIMS



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Single-well Structures



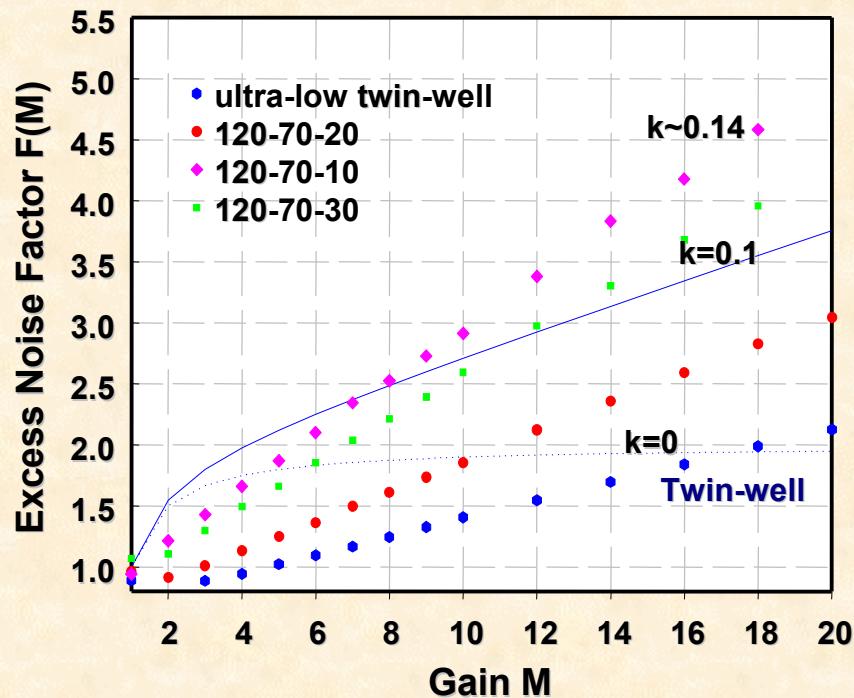
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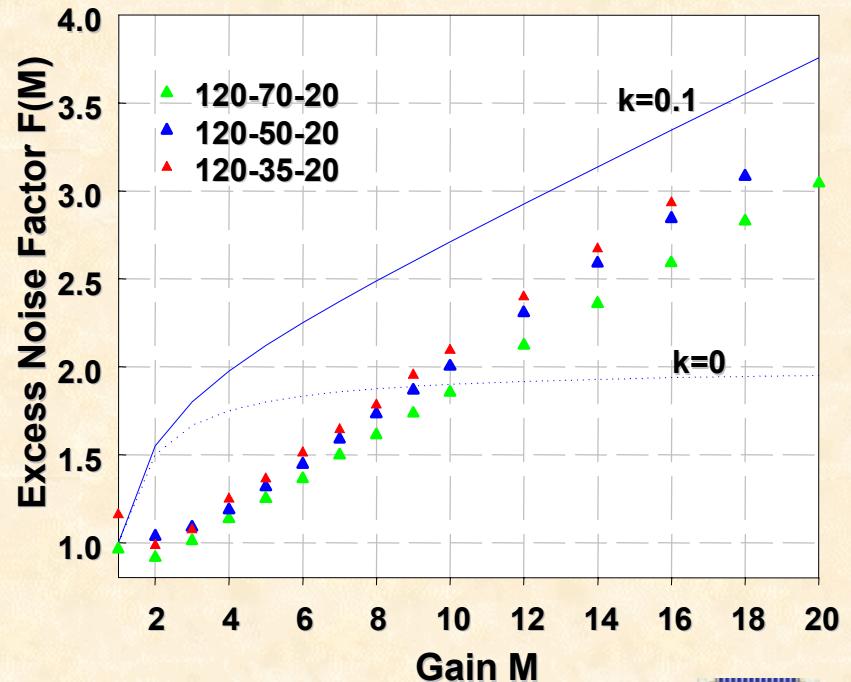
Single-well with Dopant Diffusion Offset



Spacer layer

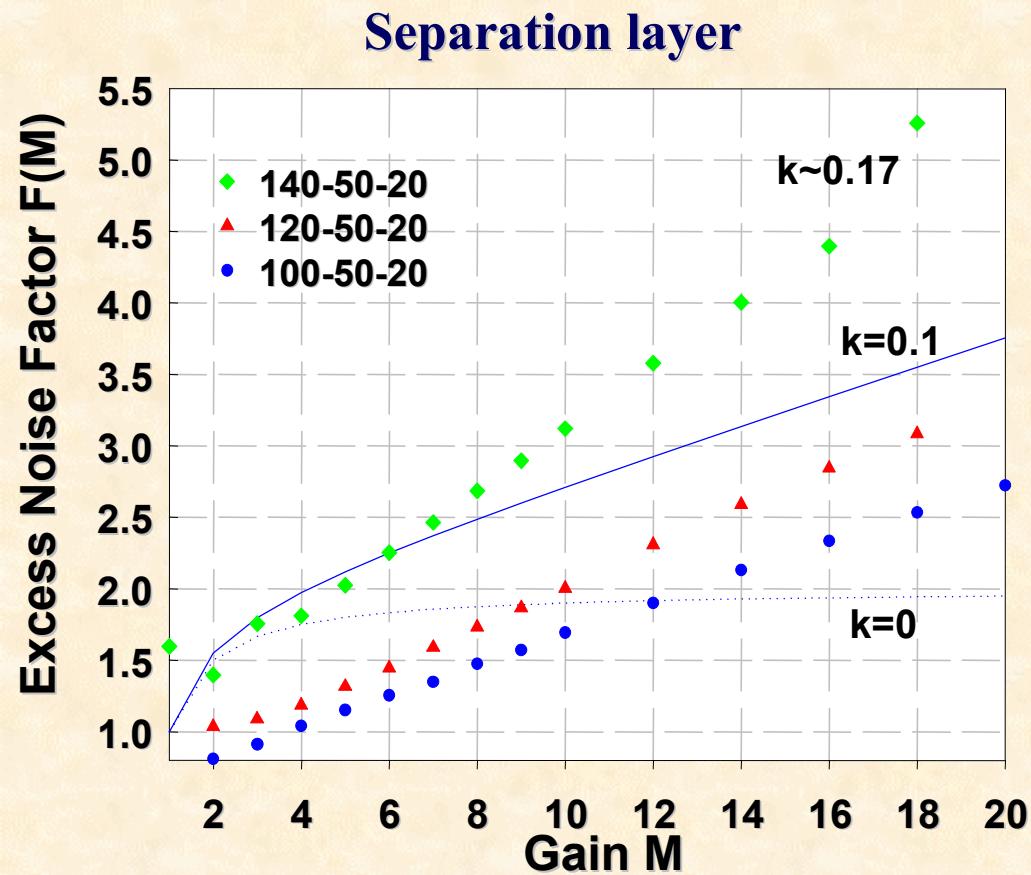


Multiplication layer



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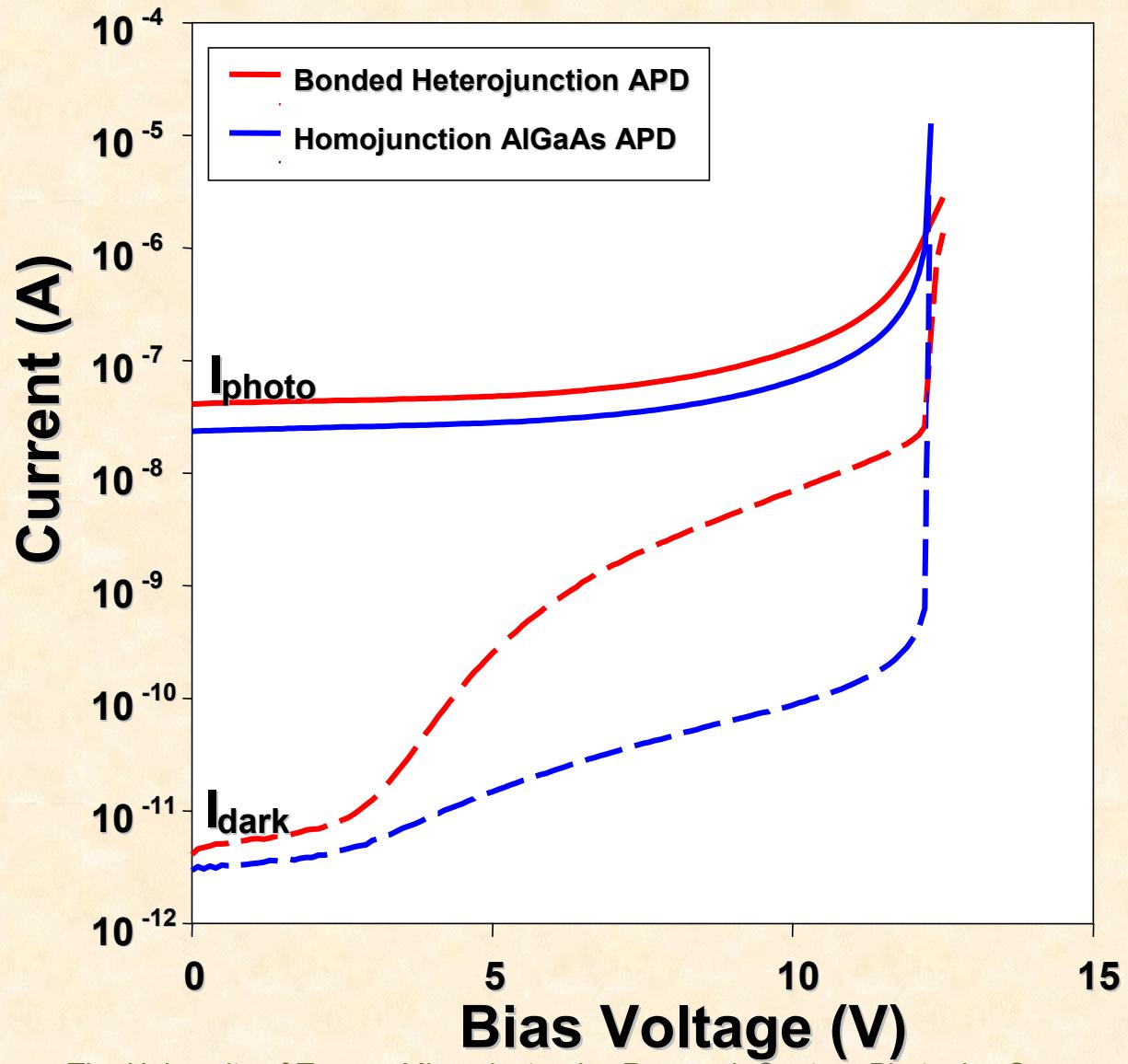
Single-well with Dopant Diffusion Offset



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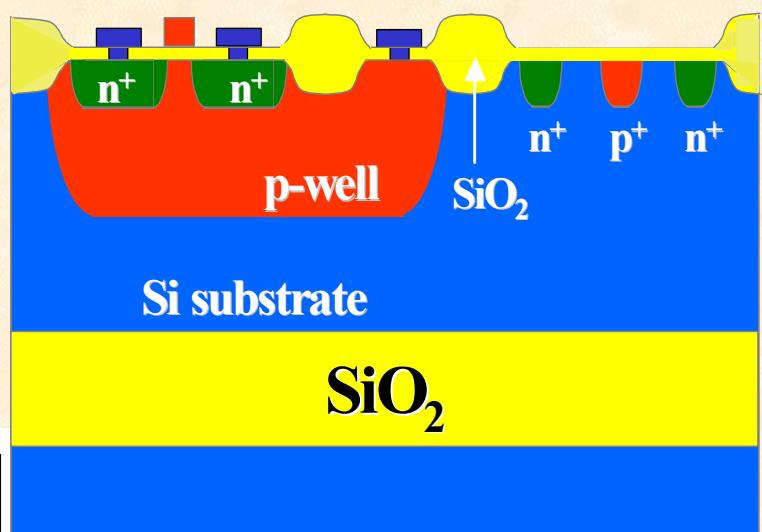
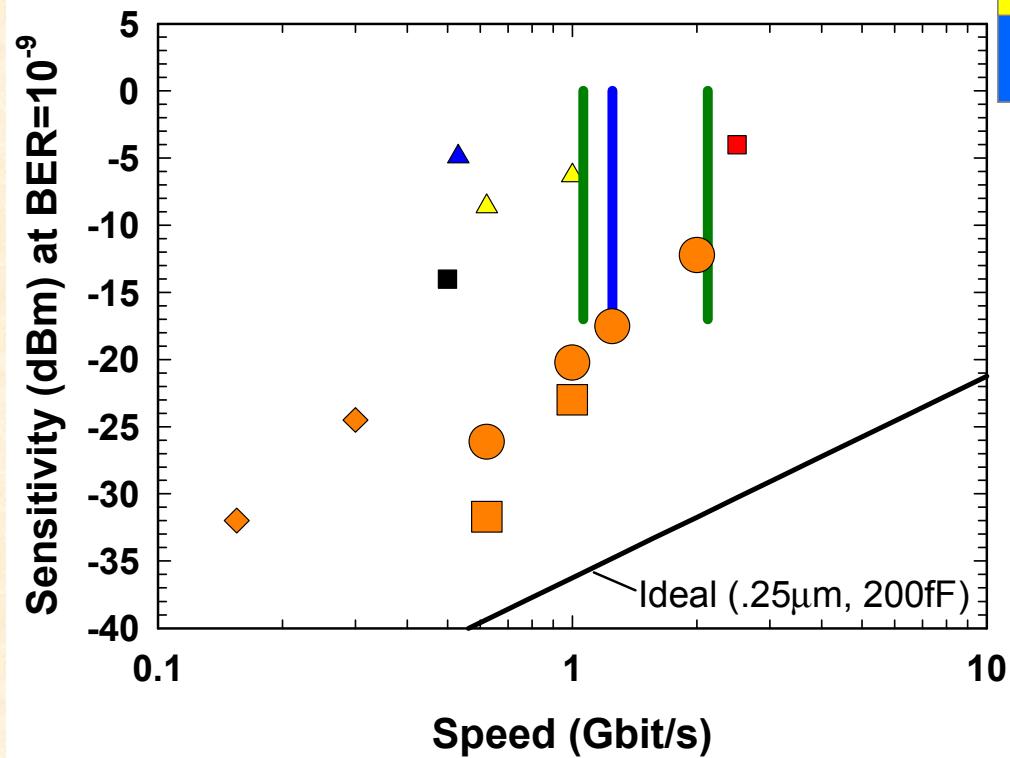


$Al_{0.2}Ga_{0.8}As/In_{0.53}Ga_{0.47}As$ Wafer-Bonded APDs



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Si NMOS Receiver

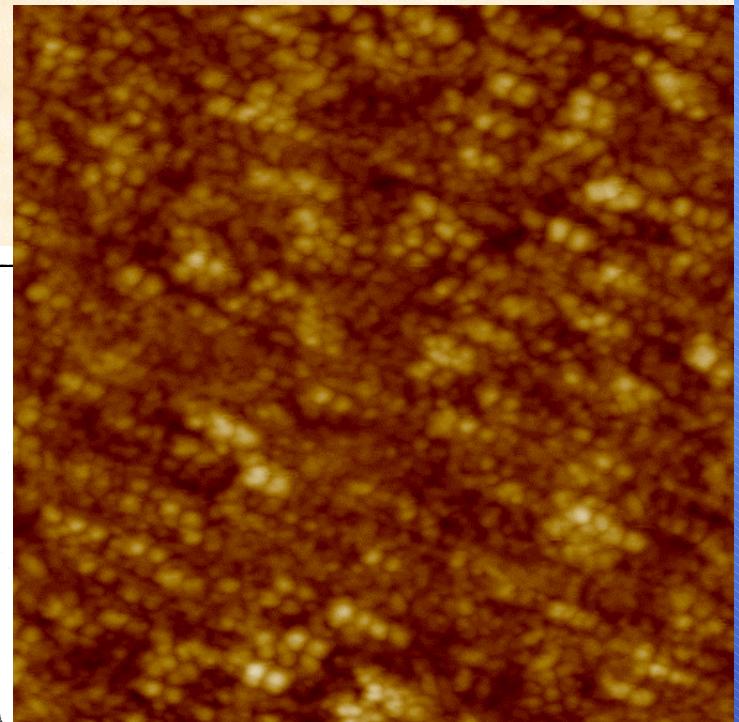
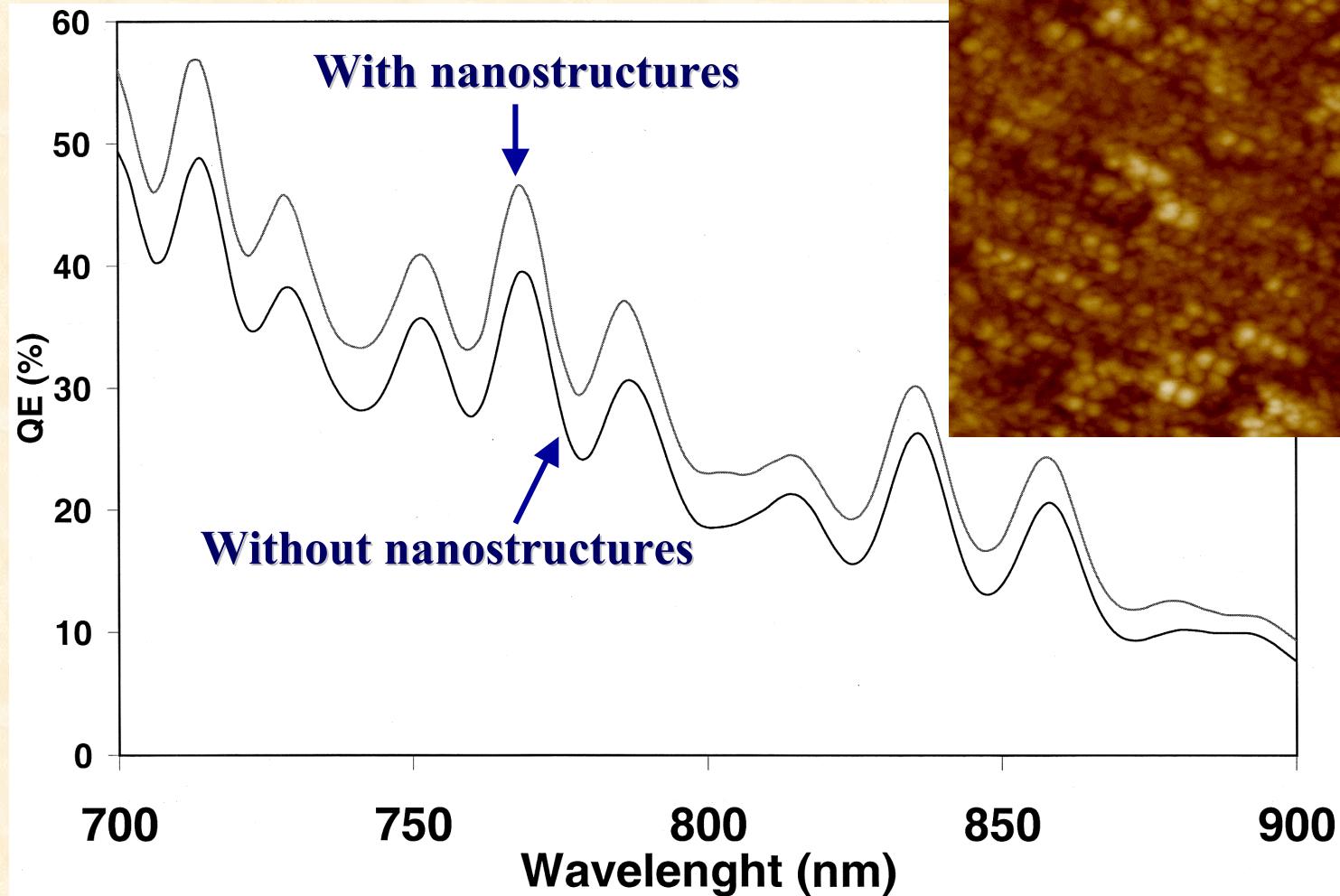


- Bipolar (non UT)**
- MOS (non UT)**
- SOI NMOS (UT)**
- HR NMOS (UT)**

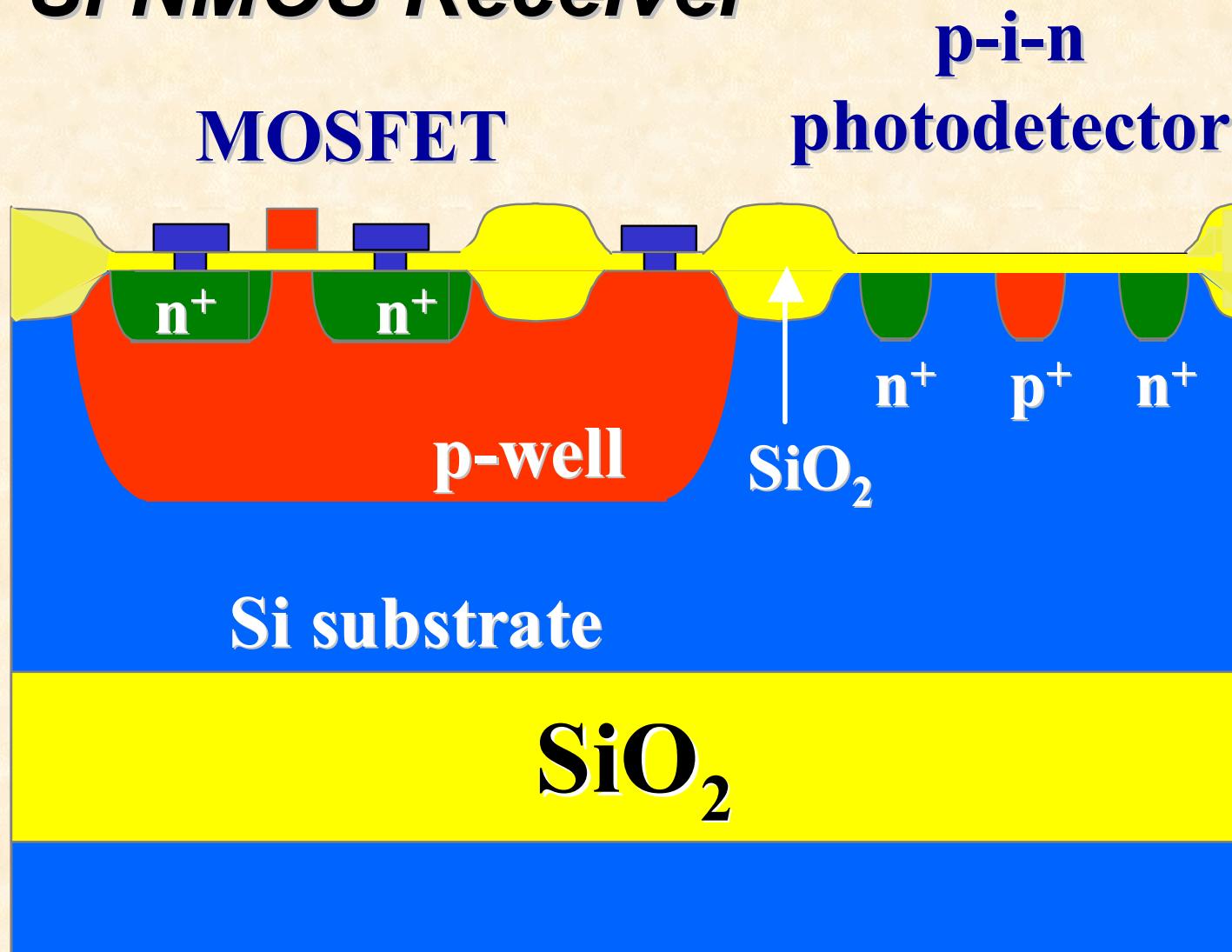


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Si Nanostructures on Si PINs



Si NMOS Receiver



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